LABORATORY MANUAL

OF

ELEMENTARY CHEMISTRY

By

J. BISHOP TINGLE

B.A. Oxford, D.Sc. Toronto, F.C.S., Professor of Chemistry
in McMaster University

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of

Elementary Chemistry

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J. Bishop Tingle

B.A. (McMaster), Ph.D. (Munich), F.C.S. Professor of Chemistry at McMaster University

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THE FOLLOWING APPARATUS CONSTITUTE A "SET"

1. 12 Test Tubes.
2. " " Stand.
3. Brush.
4. Holder.
5. Tongs.
6. 1 inch Platinum Wire.
7. Box Matches.
8. File, Triangular.
9. " Round.
10. Blow-pipe.
11. Mortar and Pestle.
12. Sandbath.
13. Glass Tube (1 piece).
14. 4 Plates.
15. Beehive.
16. Ring Stand.
17. 3 Rings.
18. Clamp.
19. 2 Rubber Stoppers.
20. 5 Gas Bottles.
21. Deflagrating Spoon.
22. Spatula.
23. Batswing Burner.
24. Bunsen "
25. 500 cc. Flask.
26. Thistle Funnel.
27. Calcium Chloride Tube.
28. 6 inches Small Rubber Tube.
29. Tube Brush.
30. Wire Gauze.
31. Beaker.
32. Crucible and Lid
33. Funnel.
34. Packet Filter Paper.
35. Small Flask.
36. Dish.
37. Graduate.
38. Clay Triangle.
39. 2 ft. large Rubber Tube.
40. Duster.

LABORATORY MANUAL
OF
ELEMENTARY CHEMISTRY

I. Preliminary.

(1) Examine the various parts of your bunsen burner and fit them together. Light the gas and observe the flame (a) when the holes at the foot are open, (b) when they are closed. How many separate parts of the flame can you distinguish in each case?

(2) Hold a white dish successively for a moment or two in the different parts of each flame. Do the same thing with a match stick.

(3) Make 4 "bulb tubes" 2½ inches long of the shape shown, Fig. 1. (Instructions)†.

FIG. 1

FIG. 2

(4) Bend a piece of tube to this pattern (Fig. 2), rounding off the edges. †(Instructions). Give carefully the *reasons* for doing each operation in the prescribed manner. Save the tubes.

II. Chemical and Physical Change.

(1) Fuse your platinum wire to a piece of glass tube. (Instructions). Hold the wire (a) in the upper portion of the bunsen flame (nonluminous); (b) in the lower one; allow it to cool. Repeat with a piece of copper wire; classify any changes which occur into physical and chemical.

†"Instructions" means that you must ask the instructor for full directions unless you have already watched him perform the operation.

(2) Brighten with a file a small piece of iron, test with a magnet; place the iron in an open vessel, together with enough water to moisten, but not cover it, and allow to remain about three days. Test the powdery product with a magnet.

(3) Mix in a mortar a quantity of copper oxide, half the size of a small pea, with two parts of fusion mixture, and heat with the blowpipe flame. (Instructions).

(4) Place the copper wire used in experiment 1 in a test tube, add about ¼ inch of concentrated nitric acid, and warm gently; subsequently boil until the liquid is just evaporated, then heat gradually until no further change takes place. What is the final product? (Hood).**

III. Weights and Measures.

(1) Measure off on your note-book a line 6 inches in length, divide into inches, then into centimeters. (cm.)

(2) Measure from a burette 10 cubic centimeters (cc.) of water and carefully weigh it. Repeat this with 4 other portions of water, each of 10 cc. Record the results in tabular form.

(3) Repeat the preceding experiment, but use saturated solution of common salt (brine) instead of the water. Return the brine to the stock bottle.

(4) Carefully rinse out the burette, allow it to drain, and repeat experiment 3 with alcohol instead of the brine. Return the alcohol to the stock bottle.

IV. Conditions of Chemical Change.

(1) Place about ½ inch of water in each of two test-tubes; in one dissolve a small crystal of sodium carbonate (washing soda), in the other a little tartaric acid. Mix the solutions.

(2) Weigh out 5 grams each of sugar and potassium chlorate; powder each separately if necessary, then carefully and intimately mix them on a sheet of paper with a pencil; place the powder on paper in the hood, and add one drop of concentrate sulphuric acid.

(3) Compare experiments 1, 3 and 4, Sec. II.

** "Hood" means that the experiment must be done with special care in a draught cupboard.

V. Methods of Separation.

SOLUTION.

(1) Place small crystals of sugar, salt and copper sulphate (blue vitriol) in separate test tubes, add water little by little, shake, and warm after each addition until no further change takes place. What happens? Now add to one of the test tubes a little sand, to another some sawdust, and to the third a little manganese dioxide; shake well and allow to stand for 5 minutes. Can you separate the clear liquids from the undissolved solid by pouring? If so, do it; the operation is known as *decantation*. If not, can you separate by straining? This is called *filtration* (Instructions). Save the clear liquids for experiment 2.

(2) Boil each clear liquid almost to dryness in your dish (*evaporation*) and compare the taste, colour, etc., of the products with the original substance you used.

(3) Now heat them more strongly until they are completely dry.

DISTILLATION.

(4) Place about ½ inch of distilled water in a test tube, add a drop of ammonium hydroxide, shake well, and repeat the addition until the liquid has a permanent odour; now boil and smell. Evaporate the liquid to dryness.

(5) Place 200 cc. of water in a flask, add a little ammonium hydroxide as before, attach to a condenser (Instructions), boil the water and collect the condensed steam in a beaker. What becomes of the ammonia? Arrange the apparatus as shown.

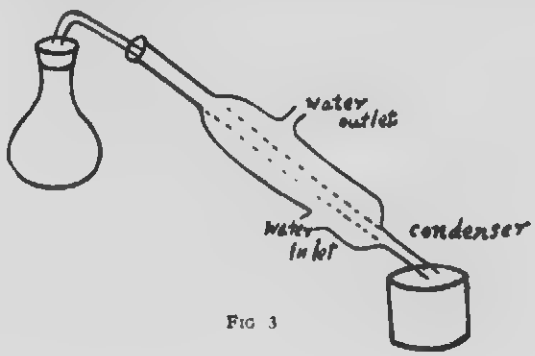

FIG 3

CRYSTALLIZATION.

(6) Fill a test tube one-third with water, add little by little potassium nitrate (saltpetre, nitre), shake well after each addition, and heat to boiling. When the solid no longer dissolves, add a few drops of water, heat again, and repeat if needful until a clear solution is obtained. Place the hot test tube in a beaker of boiling water and allow it to cool slowly.

(7) Repeat experiment 6, but use common salt (sodium chloride) instead of potassium nitrate. What differences, if any, do you observe in behaviour between the salt and nitre? Examine the contents of the cold test tubes with a lens.

(8) Boil up the solutions obtained in experiments 6 and 7, adding a few drops of water if necessary to obtain complete solution, mix the boiling liquids, allow to cool, and examine as before.

(9) Dry with filter paper a small quantity of the product obtained in experiment 8, and place it in a bulb tube (Sec. 1, Experiment 3). (Instructions). Heat slowly in the flame.

(10) Repeat experiment 6 with copper sulphate (blue vitriol) instead of potassium nitrate. After examining the product, repeat experiment 9 with it.

(11) Repeat experiments 6, 7 and 8 with potassium nitrate and potassium chlorate, instead of potassium nitrate and sodium chloride.

SUBLIMATION.

(12) Fill the bulb of a bulb tube one-quarter with ammonium chloride (sal ammoniac), heat gently in the flame until no further change takes place.

(13) Repeat experiment 12 with sugar instead of ammonium chloride.

(14) Repeat experiment 12 with sulphur instead of ammonium chloride.

VI. States of Matter.

PROPERTIES OF GASES.

(1) Fit a test tube air tight (Fig. 4) (Instructions) with a tube (Experiment 3, Sec. I), as shown. Clamp it to the stand and allow the open end to dip below water in the pneumatic trough. Heat the test tube gradually; when it is too hot to handle, allow it to cool. Heat again. Explain the result.

FIG. 4

(2) Fit a test tube air tight (Fig. 5). The projecting limb of tube A should be about 6 inches in length. Apply the lips at A and suck. Place a moist finger tightly over the end B, and suck again. Dip B below water in the trough and again suck; remove the lips from A. Explain the results.

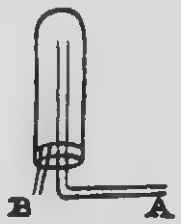

FIG. 5

PROPERTIES OF LIQUIDS.

(3) Fit a test tube with a tube about 12 inches long (Fig. 6), completely fill the test tube with water, force in the stopper, and mark the height of the water in the narrower tube by means of a string. Attach it to the stand by means of the clamp and heat gradually nearly to boiling; again observe the height of the water. Allow to cool and observe once more.

FIG. 6

(4) Apply the lips to the open end of the tube after the completion of experiment 3 and blow as vigorously as possible. What effect has this on the height of the water? (Instructions).

PROPERTIES OF SOLIDS.

(5) Heat the platinum wire in the nonluminous flame. Do you observe any alteration in the size of the wire when it is hot but nonluminous?

(6) Place a few drops of mucilage in a dish, evaporate to dryness on the water bath. (Instructions) and examine the residue with a lens. (Comp. experiment 7).

(7) Dissolve a few fragments of shellac in ½ inch alcohol and repeat experiment 5 with the solution instead of mucilage. Examine also with a lens fragments of glass, some bits of lump sugar and some granulated sugar. Compare the results with those observed in experiments 6, 7 and 8, Sec. V. How can you classify solids? Explain the characteristics of each class, and give as many examples as possible.

VII. Preparation and Properties of Oxygen.

(1) Fill one-third the bulb of bulb tube with mercuric oxide ("red precipitate"), heat it gradually to redness in the flame, and, at short intervals, insert a glowing match stick into the open end of the tube. Examine the contents of the tube when hot and again when cold.

(2) Repeat experiment 1 with red lead (oxide of lead) in place of mercuric oxide.

(3) Repeat experiment 1 with manganese dioxide (manganese peroxide) instead of mercuric oxide.

(3a) Repeat experiment 1 with lead peroxide instead of mercuric oxide.

(4) Repeat experiment 1 with potassium chlorate instead of mercuric oxide. Save the tube and contents for experiment 7.

(5) Repeat experiment 1 with an intimate mixture of equal parts of manganese dioxide and potassium chlorate. Save the tube and contents for experiment 8. Tabulate the results of experiments 1 to 5. By which method is oxygen obtained the most easily?

(6) Dissolve a crystal of potassium chlorate in about ½ inch of distilled water in a test tube, add two or three drops of dilute nitric acid, and one or two drops of silver nitrate solution.

(7) Repeat experiment 6 with the residue obtained in experiment 4 instead of potassium chlorate.

(8) Boil up the tube and contents obtained from experiment 5 with about 1 inch of water in a test tube, filter the hot acid and test the clear filtrate with nitric acid and silver nitrate as in experiments 6 and 7. Tabulate the results.

(9) Fit a test tube with a stopper and delivery tube as shown in Fig. 4. Place in the test tube an intimate mixture of 10 grams of potassium chlorate and 5 grams of manganese dioxide; see that the apparatus is air tight. Heat the test tube gently and collect the gas which comes off in wide-mouthed bottles, over the pneumatic trough. (Instructions). Perform the following experiments with the gas you obtain:

(10) Dry and clean the deflagrating spoon, put a small piece of charcoal in the bowl, ignite the charcoal, observe how it burns in the air; now lower it into the bottle of oxygen. When the experiment is completed cover the mouth of the bottle with a glass plate and set aside for experiment 13.

(11) Cool and dry the deflagrating spoon and repeat experiment 10 with a quantity of red phosphorus the size of a pea, instead of the charcoal. (Hood).

(12) Repeat experiment 11 with a fragment of sulphur instead of the phosphorus. (Hood).

(13) Pour a few drops of blue litmus solution into each of the bottles used in experiments 10, 11 and 12. Shake well.

(14) Place half an inch of water in each of 4 test tubes, colour the water with blue litmus solution, and drop by drop, until no further change takes place; add—to the first, dilute sulphuric acid; to the 2nd, dilute hydrochloric acid; to the 3rd, dilute nitric acid; to the 4th, acetic acid. Compare the results with those in experiment 13. What inference do you draw from them? Save the contents of the test tubes for experiment 17.

(15) Cover the bottom of a jar of oxygen with some sand, fray out the end of a piece of picture wire 4 inches long, heat the frayed end to redness and plunge it into the jar of oxygen, holding the wire with the tongs. Examine the product and test with litmus solution as in experiment 13.

(16) Repeat experiment 12 with a bit of sodium instead of sulphur. Test the product in the spoon with red litmus solution obtained as in experiment 14.

(17) To one of the test tubes with red litmus solution obtained in experiment 14, add sodium hydroxide solution drop by drop until no further change takes place. Do the same to the other, using ammonium hydroxide instead of sodium hydroxide.

(18) Add 6 drops of sodium hydroxide solution to half a test tube of distilled water, shake, and taste the mixture; repeat, using ammonium hydroxide in place of sodium hydroxide. Compare the results of experiments 16, 17 and 18 with each other, and with experiment 15 on the one hand and experiments 10 to 14 on the other.

VIII. Preparation and Properties of Hydrogen.

(1) Place a small bit of zinc in a test tube, cover it with dilute hydrochloric acid, warm gently if needful and, after a few moments, insert a lighted match into the mouth of the tube.

(2) Repeat experiment 1, using dilute sulphuric acid in place of the hydrochloric acid.

(3) Repeat experiment 2, using dilute nitric acid in place of the sulphuric acid.

(4) Repeat experiments 1, 2 and 3 with iron turnings instead of the zinc. Which method would you employ for making hydrogen in larger quantity?

(5) Fit up a flask as in Fig. 7.

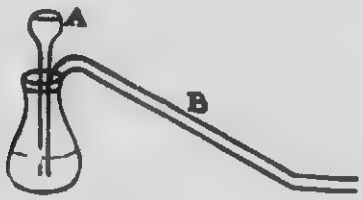

FIG. 7

A is a thistle funnel; the end of the tube B dips below the beehive of the pneumatic trough. Cover the bottom of the flask with the metal you have selected as the result of the preceding experiments. See that the apparatus is air tight. Add the acid you decide to use through the thistle funnel, and collect the gas which is evolved in a test tube; apply a

flame to the mouth of the test tube, fill a second one and do the same and continue this until two successive tubes of gas behave alike and burn with only a very slight report. Then collect 5 bottles of the gas for the following experiments:

(6) Apply a light to a bottle of hydrogen.

(7) Take a bottle of hydrogen mouth downwards, hold a lighted match with the tongs and push the light up into the bottle, remove the match, again light it and insert into the bottle.

(8) Cover a bottle of air with a plate, do the same with one of hydrogen, bring the bottles and plates together as in Fig. 8, remove the plates quickly, bringing the mouths of the bottles together, and invert them so that the hydrogen is below; allow to remain for 2 minutes; slip in the plates again and test each bottle with a light.

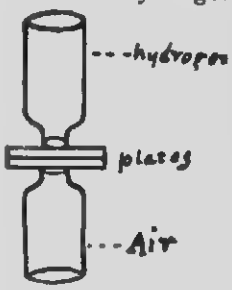

Fig. 8

(9) Place a bottle of hydrogen on the bench, slide off the plate and allow to remain for 1½ minutes, test with a light.

(10) Repeat experiment 9, but support the bottle mouth downwards from a ring on your stand. What properties of hydrogen do you deduce from experiments 6 to 10?

(11) Remove the tube B from the flask (Fig. 7) and in its place insert a short right-angled tube (A) (Fig. 9), with a calcium chloride tube (B) attached; connect the calcium chloride tube with a tube 9 inches long (C) and connect (C) with a longer tube (D) which can dip below water in the pneumatic trough. Place in (C) a few fragments of copper oxide, expel the air and then heat the oxide gently. (Instructions).

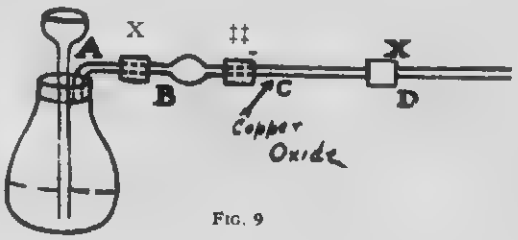

Fig. 9

x rubber connections.

‡‡ rubber stopper

(12) Repeat experiment 11 with a little ferric oxide (iron rust) in place of the copper oxide. When no further change is noticed, allow the tube to cool, and test the product and the original rust with a magnet.

(13) Take care that all air is expelled from the apparatus (Fig. 9) and light the hydrogen at the end of the tube, C; hold a clean dry test tube of water in the flame for a few seconds. Remove and examine the outside quickly.

(14) Repea experiment 13, but use a small bunsen flame instead of the hydrogen flame.

IX. Water.

(1) In the laboratory apparatus provided, electrolyse acidified water, collect the evolved gases separately in test tubes and test each with a lighted match.

(2) Tie a string round a test tube about an inch from the mouth, and with it and a second tube repeat experiment 1, taking care that each gas begins to collect at the same instant, and using the marked tube for the gas which is obtained in largest quantity. When this tube is filled almost to the mark, stop the current. Raise or lower the tube until the level of water is the same outside and inside, adjust the string to the surface of the water and remove the tube carefully. Do the same to the other tube and remove this. Now fill the first tube with water to the level of the string and measure the volume. Do the same with the second tube. Repeat the experiment 2 or 3 times, until concordant results are obtained, and calculate the ratio by volume of one gas to the other. (Note.—Two students should perform this experiment together).

(3) Taste distilled water.

(4) Fit up the apparatus (Fig. 4) and fill the test tube and delivery tube completely with water. Dip the end of the delivery tube below the beehive in the trough and place a test tube full of water above the hole of the beehive. Heat the first test tube until the water just boils, remove the flame until water runs back into the test tube, heat again, and repeat until you have collected sufficient gas to enable you to test it with a flame.

(5) Measure 50 cc. of distilled water into a clean, dry glass-stoppered bottle, add from a burette 1 cc. of soap solution, insert the stopper and shake the bottle briskly during 1½ minutes, then allow it to stand quietly; if the lather definitely persists during 3 minutes, the experiment is completed; if not, again add 1 cc. of soap solution, shake, etc., as before, and repeat as often as is necessary to obtain a permanent lather lasting at least 3 minutes. Note the amount of soap solution employed.

(6) Repeat experiment 5, but use ordinary faucet water instead of distilled water, and be careful to clean the bottle thoroughly before use.

(7) Measure 100 cc. faucet water into a beaker, boil it during 10 minutes, cool, at first in air, then in water in the trough. When cold, add enough distilled water to make up to its former volume, mix well, measure off 50 cc. and repeat experiment 6. Tabulate the results.

(8) Boil some water in a flask, suspend a thermometer as far in the neck as possible without touching the liquid. Read off the position of the mercury when it is stationary. Repeat with a Centigrade thermometer if the first one used was a Fahrenheit, and vice versa.

(9) Place both thermometers in a mixture of snow or powdered ice and water in a beaker, stir the mixture until the position of the mercury remains constant.

(10) Repeat experiment 9, but use an intimate mixture of snow or powdered ice (50 grams) and salt (16 grams).

(11) Weigh out ½ gram of crystallized sodium carbonate (washing soda), and gradually heat in a test tube, with the open end depressed, until no further change takes place. Allow to cool, remove the residue from the tube, and dissolve it in 2 or 3 drops of hot water in a test tube. Examine the product when it is cold.

(12) Repeat experiment 11 with copper sulphate (blue vitriol) instead of the sodium carbonate.

X. Air.

(1) Repeat experiments 10, 11, 12, and 13, Sec. VII, with jars of air instead of oxygen.

(2) Place a few fragments of calcium chloride in a dish and expose it to the air for about an hour. (Compare experiment 11, Sec. VIII.)

XI. Preparation and Properties of Nitrogen.

(1) Place a piece of red phosphorus about the size of 2 peas in a crucible or crucible lid. Float the crucible on water in the trough, ignite the phosphorus with a hot file handle, and quickly place a beaker mouth downwards over the crucible, pressing it firmly to prevent, as far as possible, escape of gas. When the combustion is over, allow the beaker to remain in the water until no more fumes are visible, then remove the beaker of gas and test it with a flame.

(2) Repeat experiment 1 and test the gas this time by adding 5 to 10 cc. of clear lime water, shake well, holding the plate over the mouth of the bottle.

(3) Enclose some iron turnings in a small bag of cheese cloth, fasten the bag to a wire. Determine and note in your book the capacity of the largest test tube you can obtain. Place the test tube full of air with its mouth below the water in a trough, push the wire and bag up into it, raise the test tube about ¼ inch from the trough bottom, but with its mouth below the water, and fasten it in position with your stand and clamp. Mark the test tube with your name and allow to remain 5 days, or until no further change takes place. When this is the case, remove the wire and bag, raise or lower the tube until the water is at the same level inside and outside, mark the volume of gas with string, remove the tube carefully, test quickly with a flame, then add a little blue litmus and shake well. Determine the volume of gas which you obtained and calculate its ratio to that of the original air you employed.

XII. Preparation and Properties of Ammonia.

(1) Mix about 1 gram of ammonium chloride (sal ammoniac) with twice its weight of slaked lime (calcium hydroxide), place the mixture in a test tube, warm gently, and smell the evolved gas carefully. Hold a piece of moist red litmus paper over the mouth of the test tube.

(2) Repeat with sodium hydroxide (caustic soda, sodium hydrate) solution in place of slaked lime.

(3) Fit up a test tube as in Fig. 10, with its mouth slightly inclined downwards; the tube A should be 8 inches long from the bend. Place in the test tube an intimate mixture of 5 grams of ammonium chloride and 10 grams of slaked lime; nearest to the open end of the tube place a few small pieces of quick lime; tap the tube before placing it in position, so as to leave a clear space at the upper side for the passage of the gas, and heat gently. Collect the gas in dry bottles placed mouth downwards over A.

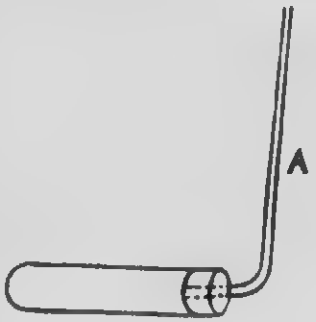

FIG. 10

(4) Place some water in a beaker or dish, colour it with a little red litmus solution. Cover the mouth of a bottle of ammonia with a dry plate, place below the water in the dish, remove the plate and shake the bottle gently.

(5) Test a jar of ammonia with a light.

(6) Pour a few drops of concentrated hydrochloric acid into a gas bottle, shake well so as to distribute the acid evenly, then bring the mouth of the bottle into contact with that of a bottle of ammonia, the latter being above; remove the plate, and invert the bottles so that the ammonia is now below. Collect some of the product, dry it on filter paper and smell and taste it. The method of collecting ammonia described in experiment 3 is called "upward displacement." Why is it adopted in this case?

(7) Pour 5 cc. of ammonium hydroxide (ammonia water) in an evaporating dish and evaporate to dryness. Test the vapour during the evaporation by smelling and by holding in it a piece of moist red litmus paper.

(8) Measure 20 cc. of ammonium hydroxide into a dish, add gradually dilute hydrochloric acid, stir the liquid constantly, and, when a drop scarcely affects blue litmus paper, evaporate almost to dryness. Compare the

taste and smell of the dried residue with the compound obtained in experiment 6. Mix the remainder with 2 parts of slaked lime, heat gently, and test as described in experiment 1.

XIII. Preparation and Properties of Nitrous Oxide.

(1) Heat about 2 grams of ammonium nitrate in a test tube; test the gaseous product with a glowing match.

(2) Place 6 grams of ammonium nitrate in a test tube (Fig. 4). Heat briskly and collect the evolved gas over warm water.

(3) Repeat experiments 10 to 13, 15 and 16, Sec. VII, with nitrous oxide instead of oxygen.

XIV. Preparation and Properties of Nitric Oxide.

(1) Cover a few fragments of copper with concentrated nitric acid, warm gently, test the product by smell and a flame. Evaporate the liquid almost to dryness under the hood, examine the residue, heat it strongly in a test tube and note any changes.

(2) Fit up a flask as in Fig. 7, but with a delivery tube long enough to dip below the water in the trough while the flask is being heated. Place in the flask 30 grams of copper, and cover it with a mixture of equal parts of concentrated and dilute nitric acid. Heat gently and collect the gas over water. (Hood.) Save the residue in the flask.

(3) Repeat experiments 10 to 13, 15 and 16, Sec. VII, but use nitric oxide in place of oxygen.

(4) Add oxygen bubble by bubble to a jar of nitric oxide which has not been removed from the trough. Shake well after addition of oxygen. Tabulate and compare the results of experiments 10 to 13, 15 and 16, Sec. VII; experiment 3, Sec. XIII, and experiment 3, Sec. XIV.

XV. Preparation and Properties of Nitric Acid.

(1) Place 10 grams potassium nitrate (nitre saltpetre) in a small retort, add through a funnel sufficient concentrated sulphuric acid to cover the solid, and heat carefully on a sand bath. (Instructions). Collect the distillate in a flask, cooled in a pneumatic trough.

(2) Place a drop of the acid on the finger, allow to remain a few moments and wash off. Pour a drop on a piece of calico or coloured cloth.

(3) Add some of the acid, drop by drop, to a ½ inch of indigo solution; warm after each solution addition.

(4) (Hood.) Boil about ½ inch of the acid, and, while hot, pour it on a piece of glowing charcoal.

(5) Fuse about ½ inch of potassium nitrate in a test tube, drop into it a piece of charcoal and continue heating for a few moments.

(6) Mix a little dilute nitric acid with an equal quantity of water, taste the solution, and test it with litmus.

XVI. Preparation and Properties of Carbon.

(1) Place some sawdust in a crucible, heat until no further change takes place; examine the product when it is cold.

(2) Repeat experiment 1, but cover the crucible with a lid, and do not remove this until the crucible is cold.

(3) Repeat experiment 1 with powdered soft coal instead of wood.

(4) Repeat experiment 2 with powdered soft coal instead of wood.

(5) Heat separately, in open crucibles, equal quantities of graphite (plumbago) and of the products obtained in experiments 2 and 4, and note the times required for complete combustion.

(6) Heat 2 grams of "animal charcoal" (bone-black) in a covered crucible for 5 minutes and add it, while hot, to a test tube two-thirds full of water coloured with cochineal solution, cork the tube, shake for 5 minutes. Filter the liquid.

(7) Repeat experiment 6 without animal charcoal.

XVII. Preparation and Properties of Hydrogen Compounds of Carbon.

(1) Add 3 cc. of water to 2 grams of calcium carbide in a test tube. Test with a flame.

(2) Fit up the apparatus shown in Fig. 11. A is a test tube closed with a cork, and contains wood. B, a second test tube, has a little water in the bottom. Heat A to redness; when B is full of vapour, apply a light to C. At the end of the experiment, test the liquid in B with red and blue litmus paper.

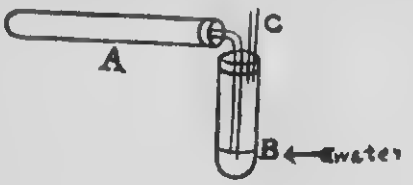

Fig. 11

(3) Repeat experiment 2 with powdered soft coal instead of wood.

XVIII. Preparation and Properties of Carbon Monoxide.

(1) Place a few crystals of oxalic acid in a test tube, cover them with concentrated sulphuric acid and warm gently. Test the gas with clear lime water (Instructions) and with a flame.

(2) Repeat experiment 1 with sodium formate or formic acid instead of oxalic acid.

(3) Repeat experiment 2 with potassium ferrocyanide (yellow prussiate of potash) instead of sodium formate.

(4) Place in the apparatus used in experiment 2, Sec. XIV, 10 grams oxalic acid, cover with concentrated sulphuric acid and heat gently with a sand-bath. Ascertain that the air is expelled, then collect 2 bottles and a large test tube of the gas and save for experiments 6, 7 and 8. Proceed immediately with experiment 5.

(5) Remove the delivery tube and substitute the tube used in Fig. 9. Repeat experiments 11 and 12, Sec. VIII, with the gas instead of hydrogen and compare results with those.

(6) Apply a light to a jar of gas; as soon as the flame disappears, cover the jar. Add a little clear lime water and shake well.

(7) Add clear lime water to the second jar of the gas, shake well.

(8) Place the test tube of gas in a dish with water, pour off as much water as possible without allowing air to enter or gas to escape from the tube, then almost fill the dish with sodium hydroxide solution, shake the tube gently from time to time, adding more solution if needful, and allow to stand for 24 hours. Transfer the tube to the trough, raise or lower it so that the height of the water is the same inside and outside, mark the height, add a little water and shake, apply a light and shake again. Determine the ratio of total gas taken to that remaining after contact with the sodium hydroxide.

XIX. Preparation and Properties of Carbon Dioxide.

(1) To 1 gram of sodium bicarbonate (baking soda) in a test tube, add a few drops of dilute sulphuric acid; test the gas with a flame and with clear lime water.

(2) Repeat experiment 1 with dilute hydrochloric acid instead of sulphuric acid.

(3) Repeat experiment 2 with dilute nitric acid instead of hydrochloric acid.

(4) Repeat experiments 1, 2 and 3 with sodium carbonate (washing soda) instead of sodium bicarbonate.

(5) Repeat experiments 1, 2 and 3 with marble or chalk (calcium carbonate) instead of sodium bicarbonate. Record the results of experiments 1 to 5 in tabular form, and state which is the best method of obtaining a steady stream of carbon dioxide.

(6) Heat separately in a crucible, without a lid, for 15 minutes, 2 grams of powdered sodium bicarbonate and sodium carbonate, and repeat experiment 2 with each residue. Tabulate results.

(7) Place in a flask (Fig. 7) 10 grams of the substance selected in view of the results of experiments 1 to 5, cover with the acid you think is best and collect the gas over water. Save the contents of the flask for experiment 14.

(8) Shake some litmus solution with a jar of carbon dioxide. (Compare experiments 10 and 13, Sec. VII).

(9) Cover the bottom of a dry, clean gas bottle with clear lime water, pour the gas from a bottle of carbon dioxide into it as you would pour water, but be careful that no water goes in, shake the bottle containing the gas and lime water.

(10) Repeat experiment 10, Sec. VII, but test the product with clear lime water.

(11) Blow gently from your lungs through half a test tube of clear lime water.

(12) Take some of the liquid remaining in the bottles used in experiments 9 to 11, add a few drops of dilute hydrochloric acid.

(13) Cover the bottom of a beaker with clear lime water and expose it to the air for several hours.

(14) Filter the liquid remaining in the flask from experiment 7, and boil it down to dryness (Hood), place some of the product on filter paper and expose to air. Save the remainder. (Compare experiment 2, Sec. X).

XX. Acids, Bases and Salts.

(1) Revise, or repeat if needful, experiments 13, 14, 16, 17 and 18, Sec. VII, and experiment 3, Sec. XIII, on acids and bases (alkalis).

(2) Repeat experiments 14 and 17, Sec. VII, with a drop of phenolphthalein solution instead of litmus.

(3) Dissolve a little of each of the following salts in an inch of water in separate test tubes, taste a drop or two of the solutions and divide them into two parts, test one part of each liquid with a drop of litmus. The salts are ammonium chloride, sodium chloride, potassium nitrate, potassium chlorate, sodium carbonate and sodium bicarbonate. Tabulate carefully the results of all these experiments.

XXI. Preparation and Properties of Hydrofluoric Acid.

(1) Mix 1 gram of calcium fluoride (fluor spar) with a little concentrated sulphuric acid in a test tube, and warm gently, smell the product, test it with a flame and with moist litmus paper.

(2) Moisten a glass rod and insert into the test tube so that a drop of water clings to the rod, which must not touch the sulphuric acid or the sides of the tube.

(3) (Hood). Warm a glass plate and rub a little paraffin over it so as to cover one side completely; when cold, draw a design in the paraffin with a match stick, taking care to remove all the paraffin from the lines; place the plate, paraffin side downwards, on a leaden dish containing 2 to 3 grams of calcium fluoride with enough concentrated sulphuric acid to form a thin paste, and gently heat the dish. Do not melt the paraffin. After 10 minutes, remove the plate, warm it and clean with a cloth and a few drops of alcohol.

XXII. Preparation and Properties of Chlorine.

(1) Heat 1 gram of manganese dioxide with ½ inch of concentrated hydrochloric acid in a test tube, smell the product, test with a flame, and observe its action on a little moist litmus paper.

(2) Repeat experiment 1 with sulphuric acid instead of hydrochloric acid.

(3) Repeat experiment 2 with a mixture of 1 gram each of manganese dioxide and sodium chloride (common salt). (Compare experiment 1, Sec. XXIII).

(4) In a flask fitted as shown in Fig. 12 (Hood), place 10 grams of manganese dioxide, cover with concentrated hydrochloric acid, shake well and heat gradually on a sand-bath. B is a test tube with about 1 inch water, and C a calcium chloride tube (compare experiment 11, Sec. VIII). D is a tube long enough to reach to the bottom of the gas bottles, which must be quite dry, and covered as closely as possible with a greased plate. Collect 7 bottles of the gas and save the liquid in the flask for experiment 13

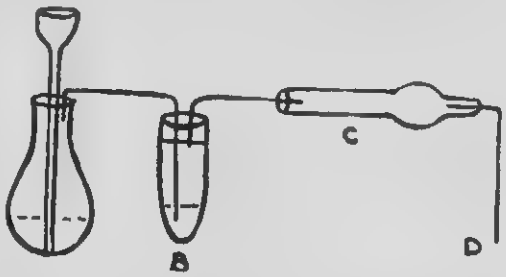

Fig. 12

(5) Place a piece of dry calico in a bottle of chlorine, after a few minutes remove it, moisten and replace.

(6) (Hood). Cover a piece of printed paper with writing ink and place it in chlorine.

(7) (Hood). Warm (not boil) a few drops of turpentin, pour it on a piece of filter paper and throw it into a bottle of chlorine; add a few drops of litmus solution to the residue and shake.

(8) (Hood). Shake a few grains of powdered antimony into a bottle of chlorine. Test the product with litmus as in experiment 7.

(9) (Hood). Dry a piece of yellow phosphorus, the size of a pea, in the deflagrating spoon, and introduce it into a bottle of chlorine. Test with litmus solution as in experiments 7 and 8.

(10) (Hood). Light a jet of hydrogen and place in a jar of chlorine (Instructions); test the product with litmus solution.

(11) (Hood). Repeat experiment 10 with illuminating gas instead of hydrogen.

(12) (Hood). Pass chlorine gently, for a few moments, into a test tube half filled with water. Examine the colour, smell and bleaching action on calico or litmus paper of the liquid.

(13) (Hood). Boil the liquid remaining in the flask from experiment 4, filter while hot, and evaporate to about one-fifth its bulk; allow to cool gradually and dry the product with filter paper.

XXIII. Preparation and Properties of Hydrochloric Acid.

(1) Cover 1 gram of sodium chloride with concentrated sulphuric acid in a test tube, warm gently, and test with a flame, litmus paper, and smell. (Compare experiment 3, Sec. XXII.)

(2) (Hood). Repeat experiment 1 with calcium chloride instead of sodium chloride.

(3) (Hood). Repeat experiment 2 with hydrochloric acid instead of calcium chloride.

(4) (Hood). In the flask fitted as in Fig. 13, place 20 grams of sodium chloride, add 25 cc. of water, then 50 cc. of concentrated sulphuric acid and heat gently on a sand-bath. Collect for experiments 5, 6 and 7, three bottles of the gas by downward displacement. (Compare experiment 4, Sec. XXII. Save the residue in the flask for experiment 11.

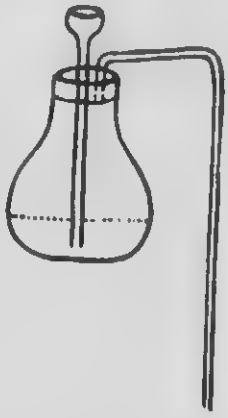

Fig. 13

(5) (Hood). Test a bottle of gas with a flame, then quickly repeat experiment 7, Sec. XXII, with the gas instead of chlorine.

(6) (Hood). Insert a jar of the gas in a dish or beaker of water coloured with blue litmus, shake. (Compare experiment 4, Sec. XII).

(7) (Hood). Repeat experiment 6, Sec. XII, with ammonium hydroxide instead of hydrochloric acid.

(8) (Hood). Allow the delivery tube of the apparatus to dip into a test tube one-third filled with water, so that the surface of the water only just reaches the end of the tube (Why?), and pass in the gas until no more is absorbed. Save the solution for experiment 10.

(9) (Hood). Remove the delivery tube from the flask, and insert a tube shaped as in Fig. 14. In the longer limb place a few pieces of zinc, then a bit of asbestos to keep them in place, pass the gas over the zinc until copious fumes escape from the tube, then heat the zinc gently, and collect any gas in a test tube over water. Test the gas in the test tube with a flame.

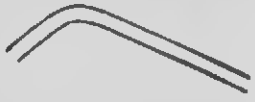

Fig. 14

(10) Treat the liquid obtained in experiment 8 with a few fragments of zinc, test any gas which you may obtain with a flame. Compare with experiment 9 and with experiment 1, Sec. VIII.

(11) Warm the residue obtained in experiment 4, filter while hot if needful, and allow to cool; if nothing is deposited, evaporate off one third of the liquid, cool again, and repeat until crystals are obtained. Dry them, taste, and compare with sodium chloride (experiment 7, Sec. V).

XXIV. Properties of Chlorine Monoxide, Hypochlorites and Chlorites.

(1) Mix 5 grams of bleaching powder (chloride of lime) with 15 cc. of water, smell the liquid, divide into 3 equal portions, place a strip of calico in each and add to one 3 cc. of dilute hydrochloric acid, to another 3 cc. of dilute sulphuric acid; compare the results on the calico of the three experiments.

(2) Cover 2 grams of bleaching powder with concentrated hydrochloric acid, warm gently if necessary, test with a flame, smell, and moist litmus paper.

(3) Repeat experiment 2 with concentrated sulphuric acid instead of hydrochloric acid.

(4) Repeat experiment 2 with potassium chlorate instead of bleaching powder.

(5) Repeat experiment 3 with potassium chlorate instead of bleaching powder, but use only a FEW GRAINS, NOT 2 GMS.

XXV. Preparation and Properties of Bromine.

(1) (Hood). Powder and intimately mix 1 gram each of potassium bromide and manganese dioxide, place in a dry test tube, cover carefully with concentrated sulphuric acid so that the sides of the tube remain clean and dry, and warm gently. Smell the product and test it with moist litmus paper. (Compare experiment 3, Sec. XXII).

(2) Dissolve ½ gram of potassium bromide in 10 cc. of cold water in a test tube, add 5 cc. of carbon bisulphide, close the tube with the thumb and shake carefully. Add 2 to 3 drops of chlorine water and shake again. Pour off the carbon bisulphide solution, smell it, and use for experiment 3.

(3) Add a little starch solution to the carbon bisulphide extract from experiment 2, shake and note any change.

XXVI. Preparation and Properties of Iodine.

(1) Repeat experiments 1, 2, and 3, Sec. XXV, with potassium iodide instead of potassium bromide.

(2) Take a little of the solution to which starch has been added (experiment 3, Sec. XXV), dilute with three times its bulk of water, and heat until no further change takes place, then cool the tube in water.

(3) Place a very small fragment of iodine in a clean dry test tube and warm gently.

(4) Place two small and equal fragments of iodine in separate test tubes, add to one 5 cc. of alcohol, to the other an equal quantity of water, shake, and note the relative solubilities. Add a crystal of potassium iodide to the aqueous solution, and shake well. Pour a little of the alcoholic solution (tincture of iodine) on the finger. Test a drop of each solution with starch solution.

XXVII. Preparation and Properties of Hydrobromic Acid and Hydroiodic Acid.

(1) Repeat experiment 1, Sec. XXIII, with potassium bromide instead of sodium chloride.

(2) Repeat experiment 1 with potassium iodide instead of potassium bromide. Compare the results of these two experiments with that of experiment 1, Sec. XXIII.

(3) Cover 1 gram of red phosphorus with bromine water in a test tube, add a drop or two of bromine if needful, warm gently, test the product with moist litmus paper and smell.

(4) Repeat experiment 3 with one gram iodine and water to cover the mixture instead of the bromine water.

XXVIII. Properties of Sulphur (Brimstone).

(1) Test the solubility of sulphur in water, alcohol, and ether.

(2) Heat, in a test tube, 10 grams of sulphur very slowly, while shaking constantly, until it boils, then pour in a thin stream into a trough of water. Save the product and examine it after several days. Use the test tube for experiment 7.

(3) (Hood). Powder a little sulphur and agitate with 5 cc. of carbon bisulphide, filter into a dish, allow the liquid to evaporate slowly and without heating, and examine the product with a lens.

(4) Repeat experiment 3 with a little of the fresh dry product from experiment 2.

(5) (Hood). Fill a crucible two-thirds with sulphur, heat gently, and when just melted, remove the flame, allow the crucible to cool until a solid crust forms. When sufficiently cold, examine the sulphur with a lens. Compare with experiment 3. The crucible may be cleaned by burning off the sulphur. (Hood).

(6) Powder 1 gram of sulphur and boil during 10 minutes with 15 cc. of a solution of sodium hydroxide; cool, filter, acidify and identify any solid that may be formed.

(7) Boil 3 to 5 grams of sulphur in a test tube, heat 4 inches of thin copper wire and hold it in the tube without touching the sides or the liquid sulphur. When the experiment is completed, warm with dilute hydrochloric acid the wire that has been acted upon. Smell the product.

(8) Mix together 1 gram each of powdered sulphur and iron filings, heat to redness in a bulb tube, cool the product, examine carefully, test with a magnet and with hydrochloric acid as in experiment 7.

XXIX. Preparation and Properties of Hydrogen Sulphide (Sulphuretted Hydrogen.)

(1) (Hood). Add, in a test tube, a little dilute hydrochloric acid to 1 gram of ferrous sulphide. Test with a flame, smell, and filter paper moistened with lead acetate solution (lead paper). (Compare experiments 7 and 8, Sec. XXVIII).

(2) (Hood). Repeat experiment 1 with dilute sulphuric acid instead of hydrochloric acid.

(3) (Hood). Collect, over warm water, a jar of hydrogen sulphide from the generator; apply a light, pushing it well inside the jar, observe the smell of the product.

(4) (Hood). Fill a test tube one-seventh with warm water, invert in the trough, displace the water with hydrogen sulphide, and apply a light.

(5) (Hood). Slowly bubble hydrogen sulphide through a test tube one-half full of cold water for 5 minutes. Smell the liquid, cork the tube, label it with your name and expose it to light for several days.

(6) Add a few drops of the liquid from experiment 5 to two-thirds of a test tube of water, shake, smell, add to the solution 2 grams of finely divided animal charcoal, cork and shake well for at least ten minutes, smell the liquid and, if needful, shake again. (Compare experiment 6, Sec. XVI).

(7) Mix half an inch each of concentrated and dilute nitric acid, warm and pass hydrogen sulphide through the liquid.

(8) Dissolve 1 gram of each of the following substances in separate test tubes two-thirds full of water: Copper sulphate, ferrous sulphate, manganese chloride, calcium chloride, and sodium chloride. To half of each of the solutions add ammonium hydroxide until, after shaking, the liquid smells of ammonia; filter if needful, then pass hydrogen sulphide slowly through the liquid for 3 to 4 minutes. Acidify the other half of the solution with dilute hydrochloric acid (test acidity), and treat in the same manner with the gas.

XXX. Preparation and Properties of Sulphur Dioxide (Sulphurous Anhydride).

(1) (Hood). Heat a few fragments of copper with a little concentrated sulphuric acid. Test the product with a flame, smell, and with paper moistened with potassium chromate or bichromate solution.

(2) (Hood). Repeat experiment 1 with charcoal instead of copper.

(3) (Hood). Repeat experiment 2 with sulphur instead of charcoal.

(4) Add a little dilute sulphuric acid to half a gram of sodium sulphite, test as above. Compare the results of the above 4 experiments with those of experiments 1 to 4, Sec. XIX; experiment 12, Sec. VII, and experiment 1, Sec. X.

(5) (Hood). Place 15 grams of copper in a flask fitted as in Fig. 13. Cover with concentrated sulphuric acid, and heat on a sand-bath. Collect 2 jars of the gas by downward displacement, and save contents of the flask for experiment 11.

(6) Test a jar of sulphur dioxide with a light.

(7) Invert a jar of the gas in a trough or beaker and shake well. (Compare experiment 4, Sec. XII, and experiment 6, Sec. XXIII).

(8) Bubble the gas through half a test tube of water, coloured with blue litmus solution.

(9) Repeat experiment 7, Sec. XXIX, with sulphur dioxide instead of hydrogen sulphide.

(10) Colour a test tube of water with cochineal solution, divide into two parts, save one for comparison, and pass a few bubbles of the gas through the other. (Compare experiments 5 and 6, Sec. XXII).

(11) Place a coloured flower in a bottle of sulphur dioxide; if the colour is affected, plunge the flower into a little dilute sulphuric acid.

(12) (Hood). Pour the contents of the flask (experiment 5) into a dish and heat gently on a sand-bath until nearly dry. Cool, fill the dish with boiling water, stir well, filter, boil down the filtrate to one-third and allow to cool slowly. Dry the solid product with paper and identify it.

XXXI. Sulphur Trioxide (Sulphuric Anhydride) and Sulphuric Acid.

(1) Sulphur Trioxide. (Hood). Heat half an inch of concentrated sulphuric acid until it nearly boils, test the fumes with a flame, litmus paper, potassium chromate paper and smell. (Compare with experiments 1 to 4, Sec. XXX).

(2) SULPHURIC ACID (OIL OF VITRIOL). Place a thermometer in 10 cc. of water in a test tube, note the temperature and add 10 cc. of concentrated sulphuric acid, stir quickly and again note the temperature. Revise, and if needful, repeat experiment 2, Sec. IV; experiments 1 and 2, Sec. XVIII; experiments 1 and 2, Sec. XX, and experiments 1 to 3, Sec. XXX.

(3) Add a few drops of barium chloride solution to a very little dilute acid from 2, then add some hydrochloric acid and warm. Describe carefully any changes.

XXXII. Phosphorus and Its Compounds.

(1) (Hood). Dry a piece of yellow phosphorus the size of a pea, and place it on a sand-bath, opposite it put a piece of red phosphorus the same size; support an inverted V-shaped copper wire about 8 inches long with a ring in the manner shown in Fig. 15, and heat the wire in the middle. (Hood).

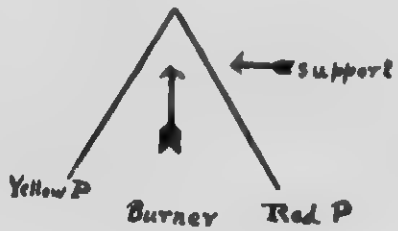

FIG. 15

(2) (Hood). Divide a piece of yellow phosphorus the size of a pea into 4 portions; dry, and cover in a test tube with a little carbon bisulphide, shake until dissolved, then pour the solution on two pieces of filter paper and allow them to remain.

(3) Repeat experiment 2 with red instead of yellow phosphorus.

(4) HYDROGEN PHOSPHIDE. (Hood). To 2 or 3 pieces of calcium phosphide, the size of a pea, add a few drops of water. (Compare experiment 1, Sec. XVII).

(5) PHOSPHORIC ANHYDRIDE AND PHOSPHORIC ACID. (Hood). Revise experiment 1, Sec. X, and repeat it with yellow phosphorus instead of red.

(6) To a few drops of sodium phosphate solution add ammonium hydroxide until it smells of ammonia, then 3 drops of silver nitrate; shake.

(7) Repeat with nitric acid and ammonium molybdate instead of silver nitrate.

XXXIII. Compounds of Silicon.

(1) SODIUM SILICATE. (WATER GLASS). Intimately mix 1 gram of finely ground sand with 3 grams of ‡fusion mixture. Place in a crucible and fuse by means of the foot blowpipe. Then boil the crucible with about 25 cc. of water, filter while hot, divide the filtrate into 3 parts and use in experiment 2.

(2) SILICIC ACID. Acidify one portion of the sodium silicate solution with dilute sulphuric acid, and the other portions with dilute hydrochloric and nitric acids, respectively. Filter and test the solubility of the residues separately in sodium hydroxide solution, dilute acids, and water.

(3) Repeat the above tests of solubility (experiment 2) with sand.

(4) Heat a little silicic acid on charcoal with the blowpipe. Place the product in a dish with a few drops of water, and rub with a glass rod.

(5) Repeat experiment 4 with sand instead of silicic acid (Revise experiments 3 and 2, Sec. XXI).

XXXIV. Compounds of Boron.

(1) BORIC ACID. (BORACIC ACID). Dissolve 1 gram of borax (sodium pyroborate) in 5 cc. water, and add CAUTIOUSLY 3 cc. of concentrated sulphuric acid; stir, cool, filter, wash with a little cold water, and dry. Use the product for experiments 4 and 5.

(2) (Hood). Mix 10 cc. of alcohol in a dish with 2 cc. of concentrated sulphuric acid, light the alcohol, and, while burning, stir with a rod.

‡ Fusion mixture is a mixture of 1.1 parts of dry sodium carbonate and 1.4 parts of dry potassium carbonate.

(3) Repeat experiment 2, but add first to the alcohol 1 gram of finely powdered borax.

(4) Repeat experiment 3 with boric acid (from experiment 1) instead of borax and sulphuric acid.

(5) Dissolve a little boric acid in 5 cc. of water, moisten a strip of tumeric paper with the solution, and allow it to dry. Note the colour, add to the paper a drop of sodium hydroxide solution.

(6) Moisten other pieces of the tumeric paper separately with sodium hydroxide solution, and dilute sulphuric acid. (Compare experiment 1 and 2, Sec. XX).

XXXV. Analytical Reactions of the Metals.

The following experiments are to be carried out with the compound specified under each metal, and the results arranged in a large table. (Instructions).

(1) Heat a little of the substance in a bulb tube.

(2) Intimately mix a little of the substance with 2 parts of fusion mixture and heat on charcoal with the blowpipe. If a metallic bead is obtained, observe its colour, relative brittleness, and its behaviour towards a few drops of nitric acid.

(3) Test with a borax bead. (Instructions).

(4) Test the flame colouration. (Instructions).

(5) Dissolve 1 to 2 grams of the substance in two-thirds of a test tube of water. Take 1 inch of the solution for each of experiments 6 and 8.

(6) Add a few drops of dilute hydrochloric acid to a solution of the substance.

(7) If no change is observed in experiment 6, pass hydrogen sulphide through the acid liquid for at least 5 minutes. If a change was produced in experiment 6, this and the following experiments are to be omitted.

(8) To a fresh portion of the solution made in experiment 5, add ammonium chloride solution and ammonium hydroxide until the liquid smells of ammonia. If a precipitate forms, omit the following experiments.

(9) To the liquid from experiment 8 add ammonium sulphide. If a precipitate is produced, omit the following experiments.

(10) To the liquid from experiment 9 add ammonium carbonate and warm gently; if a precipitate is produced, omit experiment 11.

(11) To the liquid from experiment 10, add sodium phosphate and ammonium hydroxide.

XXXVI. Sodium and Its Compounds.

(1) (Hood). Throw a piece of sodium, the size of a pea, on a dish of water; when the action is over test the water with red litmus solution.

(2) (Hood). Repeat experiment 1 with 2 pieces of wet filter paper instead of the dish of water.

(3) ANALYTICAL REACTIONS. Use sodium chloride.

(4) To half an inch of a solution of sodium chloride add an equal quantity of sodium hydroxide; boil, smell the steam and hold it in a piece of moist red litmus paper. (Compare experiment 2, Sec. XII).

(5) To half an inch of sodium chloride solution add tartaric acid solution, stir the liquid with a rod and allow it to remain for 30 minutes.

XXXVII. Potassium and Its Compounds.

(1) (Hood). Repeat experiment 1, Sec. XXXVI, with potassium instead of sodium.

(2) ANALYTICAL REACTIONS. Use potassium chloride.

(3) Repeat experiments 4 and 5, Sec. XXXVI, with potassium chloride instead of sodium chloride.

XXXVIII. Ammonium Salts.

Compounds of ammonia with acids are called ammonium salts.

(1) ANALYTICAL REACTIONS. Use ammonium chloride (sal ammoniac).

(2) Revise experiments 1, 2 and 6, Sec. XII.

XXXIX. Magnesium and Its Compounds.

(1) Burn 2 inches magnesium ribbon over a dish, add 2 or 3 drops of dilute sulphuric acid to the product. Warm until dissolved, boil down in a test tube and examine the residue with lens.

(2) Dissolve in a small test tube 2 inches of magnesium in a little dilute sulphuric acid, test the product with a flame, and treat the liquid as in experiment 1.

(3) ANALYTICAL REACTIONS. Use magnesium sulphate (Epsom Salts).

XL. Calcium Compounds.

(1) Heat a little calcium carbonate in a covered crucible for an hour. Allow to cool and add a little warm water. When no further change takes place shake the product for 10 minutes in a test tube of cold water, filter, and blow through the clear liquid. (Compare experiment 11, Sec. XIX).

(2) ANALYTICAL REACTIONS. Use calcium chloride. (Compare experiment 2, Sec. X, and experiment 11, Sec. VIII).

XLI. Zinc and Its Compounds.

(1) Heat a piece of zinc strongly in a covered crucible with the foot blowpipe. Dissolve the product in a little dilute sulphuric acid, and examine as in experiment 1, Sec. XXXIX.

(2) Repeat experiment 2, Sec. XXXIX, with zinc instead of magnesium. (Compare experiments 1, 2 and 3, Sec. VIII).

(3) ANALYTICAL REACTIONS. Use zinc sulphate (white vitriol).

XLII. Nickel Compounds.

(1) ANALYTICAL REACTIONS. Use nickel sulphate.

XLIII. Cobalt Compounds.

(1) Write a few words on a piece of note paper with a soft match stick and a dilute solution of cobalt chloride or nitrate. Allow to dry, warm gently, cool and warm again.

(2) ANALYTICAL REACTIONS. Use cobalt nitrate or chloride.

XLIV. Aluminum and Its Compounds.

(1) Warm fragments of aluminum in test tubes with separate small portions of dilute hydrochloric, sulphuric and nitric acids, and sodium hydroxide. Test the gaseous products with a flame.

(2) Dissolve 0.7 gram of potassium sulphate and 3.2 grams of aluminum sulphate separately in the least possible quantities of boiling water, allow the solutions to cool slowly (experiment 6, Sec. V) and examine them with a lens. Boil up again, with the addition of a little water if needful; mix the hot solutions, and allow the mixture to cool slowly in a beaker of boiling water. Examine the product with a lens and compare it with its constituents. Dry it with filter paper and test a little of it for potassium (experiment 3, Sec. XXXVII), and use some of the remainder for the analytical reactions of aluminum.

(3) ANALYTICAL REACTIONS. Use the product from experiment 2.

XLV. Iron and Its Compounds.

(1) Revise and, if necessary, repeat experiment 4, Sec. VIII, and experiment 3, Sec. XI.

(2) Dissolve a little iron in dilute hydrochloric acid, divide the liquid into two parts; to one add a few drops of potassium ferrocyanide (yellow prussiate of potash), to the other a little potassium ferricyanide (red prussiate of potash) solutions.

(3) Repeat experiment 2 with a solution of ferric oxide (iron rust) in hydrochloric acid instead of iron.

(4) ANALYTICAL REACTIONS. Use ferrous sulphate.

(5) Repeat the analytical reactions with FERRIC CHLORIDE.

XLVI. Tin and Its Compounds.

(1) Bend a piece of tin close to the ear.

(2) (Hood). Heat fragments of tin with half an inch of concentrated nitric acid in a test tube; when the metal has disappeared, pour the product into a dish and evaporate slowly to complete dryness. Heat the dish gradually, allow it to cool, and test the solubility of the residue in acids, alkalis and water (Compare experiment 1, Sec. XIV).

(3) ANALYTICAL REACTIONS. Use stannous chloride.

XLVII. Gold and Its Compounds.

(1) (Hood). Test the solubility of fragments of gold leaf separately in a few drops of concentrated, PURE nitric, hydrochloric, and sulphuric acids. Save the products.

(2) (Hood). Repeat experiment 1 with a mixture of concentrated pure hydrochloric and nitric acids. Save the product.

(3) (Hood). Evaporate the liquids obtained in experiments 1 and 2, except the sulphuric acid, almost to dryness in a dish, moisten the residue with dilute hydrochloric acid, dissolve it in 100 cc. of water, and add a drop or two of stannous chloride solution.

XLVIII. Platinum and Its Compounds.

(1) (Hood). Repeat experiments 1 and 2, Sec. XLVII, with platinum wire or foil instead of gold leaf. Save the liquids.

(2) (Hood). Evaporate the liquids (except the sulphuric acid) obtained in experiment 1 to dryness, as in experiment 3, Sec. XLVII. Dissolve the residue in the smallest possible quantity of warm, dilute hydrochloric acid, and add a little hot concentrated solution of ammonium chloride; allow the liquid to cool, examine the product with a lens and save for experiment 3.

(3) Heat the product of experiment 2 strongly in a crucible; test the solubility of the residue in acids as in experiment 1. Explain clearly the changes produced in these three experiments.

XLIX. Copper and Its Compounds.

(1) Revise experiments 1 and 3, Sec. II; experiment 11, Sec. VIII; experiments 1 and 2, Sec. XIV; experiment 5, Sec. XVIII, and experiments 1 and 5, Sec. XXX.

(2) Dissolve 3 grams of copper sulphate (blue vitriol) in 50 cc. of water, take separate portions of 10 cc. each, suspend in one a piece of zinc, in another a bit of magnesium ribbon, and in the third the blade of a knife (steel or iron). Leave the first two for a couple of days.

(3) Add a little sodium hydroxide to a little copper sulphate solution; when no further change takes place, heat until the liquid boils, filter off the product, wash the solid with hot water and use a portion of it for analytical reaction No. 2. Dissolve the remainder in dilute sulphuric acid, evaporate to about one-quarter of its bulk, allow the liquid to cool slowly, and examine with a lens, etc.

(4) Add ammonium hydroxide drop by drop to a little copper sulphate solution until no further change takes place. Carefully shake after each addition.

(5) Add a few drops of potassium ferrocyanide to a little copper sulphate solution. (Compare experiments 2 and 3, Sec. XLV).

(6) Analytical Reactions. Use copper sulphate.

L. Mercury (Quicksilver) and Its Compounds.

Great care must be taken not to pour any mercury down the sink, nor to allow it to come into contact with articles of jewelry. See experiments 9 and 10 below.

(1) (Hood). Heat a few drops of mercury with 5 cc. of concentrated nitric acid for 15 minutes, or until the metal disappears. Add water and save the clear solution for experiments 2 and 3.

(2) Add sodium hydroxide to a little of the liquid obtained in experiment 1. Save the product for experiment 5.

(3) ANALYTICAL REACTIONS. For Nos. 1 to 4, use the product obtained in experiment 2, after it has been washed and dried in the air on paper. For the remaining analytical reactions, use the liquid obtained in experiment 1.

(4) Repeat experiment 1 with dilute instead of concentrated nitric acid and keep the mercury in EXCESS. Use the solution for experiments 5, 6 and 7.

(5) To a little of the solution from experiment 4 add sodium hydroxide. Save the product for experiment 6.

(6) ANALYTICAL REACTIONS. For Nos. 1 to 4, use the product obtained in experiment 5 after washing and drying it in the air. For the remainder, the liquid obtained in experiment 4.

(7) To a portion of the liquid from experiment 4 add a little dilute hydrochloric acid. Determine whether the product is soluble in hot water. Add to a portion of it ammonium hydroxide.

(8) Dilute some of the liquids obtained in experiments 1 and 4 with an equal bulk of water, and in separate test tubes half full of the liquid, suspend pieces of zinc, iron and copper (6 test tubes in all), label the tubes, and set aside for a day or two.

(9) Moisten a piece of zinc with a drop of dilute nitric acid, pour a drop of mercury on the wet surface and quickly rub it with a cloth.

(10) Repeat experiment 9 with a piece of copper or copper wire instead of zinc.

LI. Lead and Its Compounds.

(1) Treat fragments of lead separately with the following acids: Cold and hot; dilute and concentrated; hydrochloric, nitric, sulphuric. Tabulate the results.

(2) ANALYTICAL REACTIONS. Use lead nitrate.

(3) Repeat experiments 7, Sec. L, with lead nitrate solution instead of the mercurous nitrate.

(4) Suspend a piece of zinc in half a test tube of lead nitrate solution and allow it to remain for a day or two.

(5) Repeat experiment 4 with pieces of iron and copper, respectively. Tabulate the results of experiments 4 and 5, and compare with experiment 2, Sec. XLIX, and experiment 8, Sec. L.

LII. Silver and Its Compounds.

(1) ANALYTICAL REACTIONS. Use silver nitrate (Lunar caustic). Repeat experiment 3, Sec. LI, with the product obtained in analytical reaction No. 3. Tabulate the results obtained, together with those of experiment 3, Sec. LI, and experiment 7, Sec. L.

(2) Place a few drops of silver nitrate solution on the fingers.